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North High School: Gender Equity Study

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North High School:
Gender Equity Study

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By

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Abstract

Past research demonstrates a strong association between men and science and women and liberal arts (Johnston & Malinen, 2007; Nosek, Banaji,, & Greenwald, 2002). Research also demonstrates that of the women who pursue science, most show a preference for biology (Berryman, 1983; LuckenBills-Eds, 2000). In the current study, we examined the attitudes students had towards science and investigated whether we could improve attitudes toward science by exposing students to engaging activities towards different areas of science. To do so, we recreated a 14-week after school science club at a local urban high school. Prior to participating, we surveyed students on their thoughts of science and engineering. Then, we ran the science club one day a week for 14 weeks. Each week, we completed a project pertaining to a different area of science and engineering (e.g., building a bridge out of popsicle sticks discussing physics and civil engineering). After the completion of the 14-week period, we surveyed students again. We found that all students initially preferred biology over chemistry and physics, but after the 14-week exposure period, all students like biology, chemistry, and physics equally. Contrary to past research, we found no gender differences in preferences towards science (including biology); rather, we were able to improve attitudes towards physical science equally.

Gender Equity at North High School

"*The innate aptitude of women [is] a factor behind their low numbers in science and engineering.*" -- Larry Summers (2005), former president of Harvard University.

As the above quote suggests, some believe that men and women have different capabilities in science. Along these lines, research demonstrates that men are more associated with science; whereas, women are more associated with liberal arts (Johnston & Malinen, 2007; Nosek, Banaji, & Greenwald, 2002). Moreover, research also shows discrepancies in actual academic ability with men excelling to a greater degree in the physical sciences compared to women (see Johnston & Malinen, 2007). While the discrepancies between men and women's academic performance have been studied extensively, methods for reducing these biases and increasing women in underrepresented academic domains have been limited. In addition, research shows that the more familiar something is, the more individuals like it—known as the mere exposure effect (Zajonc, 1968). Given this, we investigated whether exposing students to different areas of science using engaging demonstrations and discussion could change student's attitudes towards science—especially gender attitudes.

Women and Science

In 1962, James Watson, Francis Crick, and Maurice Wilkins shared the Nobel Prize for discovering the double helix formation in the DNA structure. Investigation into the discovery shows that Rosalind Franklin, a chemist who worked closely with Watson and Crick was the first person to actually discover the double helix formation; however, she was not credited for this discovery nor did she share the Nobel Prize—most likely because she was a woman (U.S. National Library of Medicine 2008). While this example certainly demonstrates discrimination against women who pursue science, research shows that people not only associate women with liberal arts and men with science, but men are more likely to excel in the physical sciences (Johnston & Malinen, 2007; Cohen & Sherman 2002).

Moreover, research looking at implicit (or unconscious) attitudes shows that both men and women strongly associate men with math and women with liberal arts (Nosek, Banaji, & Greenwald, 2002; Sinclair, Hardin, Lowery, 2006).

These explicit and implicit attitudes can prevent women from entering more math, science, and engineering-oriented careers because society tells them this is not the place for them, and this mindset only gets reinforced when women look around and see that other women are less likely to be in these types of careers (see Social Role Theory, Eagly, 1987). Stereotype threat, or the fear of confirming the stereotypes of one's group that leads to detriments in performance due to the anxiety of trying not to confirm the stereotype, is another factor that can prevent women from pursuing science/engineering oriented careers (Steele & Aronson, 1995). Much of the stereotype threat research has looked at the detriments in academic performance that result for women and African Americans when they become aware (consciously or unconsciously) of the academic stereotypes associated with their group (Cadinu, Maas, Rosabianca, & Kiesner, 2005; Nosek, Banaji, & Greenwald, 2002; Sinclair, Hardin, & Lowery, 2006; Steele & Aronson, 1995). For instance, African Americans were given a test that was labeled as either being diagnostic of their intelligence or just an exam (non-diagnostic), and those told the test was diagnostic performed worse on the exam than those told the test was just an exam (Steele & Aronson, 1995).

The idea that the knowledge of the stereotypes of one's group is deeply internalized was highlighted in one study that investigated the effects of competing stereotypes (e.g., the stereotype that Asians are good in math and women are bad in math). In this study, Asian women came into the lab and completed a packet of information regarding their thoughts and preferences towards math and verbal tasks. Prior to completing this packet, participants either indicated their ethnicity or their gender. Those who indicated their ethnicity rated math much more favorably (in alignment with the stereotypes that Asians are good in math) than those who indicated their gender (in line with the stereotype that women are bad at math. (Sinclair, Hardin, Lowery, 2006). Thus, subtly making an individual aware of the stereotypes of the group can drastically influence their perceptions, self-evaluations, and even their performance.

In addition to the stereotype that women are less proficient in math and science, of those women who get involved in science-oriented careers, another stereotype is that they pursue biological and/or agricultural sciences (see Berryman, 1983; LuckenBills-Eds, 2000). However, enrollment rates in the 1990s suggest that women earn half the bachelor degrees in biological/agricultural sciences, and were on par with men for their enrollment in college-level courses in biochemistry, genetics, organic chemistry, algebra, and statistics (LuckenBills-Eds, 2000).

Thus, the attitude that women do not excel in science, math, and engineering pervades the minds of others and the minds of women —even those who pursue these academic career paths. While much of this research looks at what prevents women from excelling in these fields (Johnston & Malinen, 2007; Nosek, Banaji,, & Greenwald, 2002; Sinclair, Hardin, Lowery, 2006), very little research examines what can be done to change the perceptions of the attitudes towards women pursuing science, change that attitudes that women will only pursue biology, and get interested in all types of science, engineering, and math.

Exposure

If both men and women strongly believe that men are not associated with math, science, and engineering, the question that remains is how we can change the attitudes, especially of women, to see themselves as scientists, mathematicians, and engineers. Research investigating methods of reducing stereotypes, prejudice, and discrimination have suggested several different methods to promote egalitarian attitudes between two groups--such as increasing exposure to members of the outgroup to make them seem more similar to the in-group (Slavin & Madden, 1979; Green, et al., 1988 as cited in Myers, 2007), encouraging cooperation between the two groups (Aronson, 1978 as cited in Myers, 2007; Sherif,1966 as cited in Myers, 2007; Slavin & Cooper, 1999), and introducing superordinate goals, or goals that both groups strive to achieve but can only be attained by cooperation between all parties (Blake & Mouton, 1979 as cited in Myers, 2007; Sherif, 1966 as cited in Myers, 2007).

Applying these methods to improving the attitudes towards science by having men and women work cooperatively on scientific and mathematical problems and giving the co-ed teams a superordinate goal while working together should help improve attitudes towards science. Likewise, increasing the exposure of individuals who are interested in science (all types—not just biology), math, and engineering should also help change the attitudes towards math and science. And, as the Social Role theory (Eagly, 1987) suggests, once more women are involved in all areas of science, math, and engineering, then they will be perceived as scientists, mathematicians, engineers, and then more women will pursue these areas.

While these methods will help improve general attitudes towards science, these methods may not intially get women interested enough in science, math, and engineering to pursue these career paths. Getting interested is the first step because after women begin to pursue these academic career paths, then individuals will be exposed to women in science, and initiating cooperation and superordinate goals between the co-ed groups on projects will become important tools. Thus, the question remains—how do we encourage women to become interested in science? Looking at the persuasion literature, research suggests that the more exposure (or familiarity) an individual has to a particular stimulus, then the more that stimulus is liked (Zajonc, 1968). For instance, in one study (Zajonc, 1968), participants repeatedly saw 25 different Chinese characters. Then, they saw some a mixture of new and previously seen Chinese characters, and had indicated their preference for each character. Participants showed a strong preference for the Chinese characters that had been previously seen (Zajonc, 1968). Applying this idea behind our problem, we wondered if increasing mere exposure to different areas of science would increase liking towards these different areas of science, especially for women.

Current Study

In the current study, we set out to explore whether exposing students to different areas of science would influence their attitudes towards the different areas of science. To do so, we created an after-school science club that was intended to pose engaging research questions in different areas of science and include hands-on activities in these areas. Prior to participating in the science club, we assessed student's attitudes towards different areas of study and after the 14-week program we reassessed their attitudes to see if they changed. Based on past research, we predicted that initially women would prefer liberal arts to science (Cadinu, Maas, Rosabianca, & Kiesner, 2005; Johnston & Malinen, 2007; Ngo & Souza, 2007; Nosek, Banaji, & Greenwald, 2002; Sinclair, Hardin, & Lowery, 2006;). Since the stereotype is that women involved in science prefer biology, we also predicted that women would initially prefer biology to all other areas of science (LuckenBills-Eds, 2000; Ngo & Souza, 2007). Finally, we predicted that mere exposure to the different areas of science would have a similar effect that it had in past attitude formation research and would increase positive attitudes towards all areas of science, especially physical science--physics and chemistry (Cohen & Sherman, 2002; Zajonc, 1968)—and that this effect would be greater for women.

Method

Participants

Twenty-seven high school students (14 women; 13 men) from a local urban high school participated in this study and included 10 Ninth graders, 5 Tenth graders, 9 Eleventh graders, and 3 Twelfth graders. In each of the 14-week sessions, participation varied from 4 to 15 students. All students were offered snacks and beverages at each session, and four of the students earned extra credit in their science course for participation. On occasion, prizes were administered as rewards for active verbal participation in the learning sessions. Fourteen participants attended too few sessions (1 was too few); therefore, the analyses of the final questionnaire are based on 13 participants (9 women, and 4 men).

Design and Materials

Our study implemented a within-participants design. Each participant completed an assessment of their attitudes prior to participating in the 14-week exposure to different areas of science sessions, and each participant completed the same assessment after the 14-week period ended. Each week, the students were exposed to topics and projects in different areas of science and engineering (e.g., biology, chemistry, civil engineering).

Questionnaire. Both the pre-exposure and post-exposure questionnaires assessed participants attitudes towards different areas of study, including art, biology chemistry, English, history, math, and physics. In addition, the questionnaire asked participants in their anticipated college major, what they thought of the word engineering, and to indicate their favorite classes in high school, and their favorite project over the 14-weeks.

Science Projects. Each week students were exposed to different science projects. For instance, participants learned about biology through a demonstration on camouflage through the use of M&Ms and colored paper and participants learned about physics and civil engineering in building bridges out of popsicles project. (See Appendix A for a complete list of the projects and materials needed for the projects).

Procedure

Participants were recruited through a local high school to join an after school science club program. Participants obtained parental permission to participate in after school programs prior to participating. One high school teacher offered extra credit to students to encourage participation in the program. On the first session, the participants anonymously completed the pre-exposure survey under the cover story that we were interested in understanding what areas of study interested them in order to better design the projects conducted over the 14-weeks. If any student missed the first session, they were given the pre-exposure survey at their first session and the week they joined was noted on their survey. Over the course of the 14-week period, the participants were exposed to a different science project that would engage them in that particular area of study. For instance, to expose participants to civil engineering, they built bridges out of popsicle sticks and discussed elements of civil engineering and physics. Over the 14-week period, participants were exposed to projects that covered the following topics: biology, physics, chemistry, civil engineering, material science, electrical engineering. At the end of the last session, participants were again given the same questionnaire given the first week to reassess their attitudes towards different areas of science (see Appendix B for the Questionnaires).

Results

Does Exposure to Different Areas of Science Matter?

To assess whether exposure to the different areas of science changed attitudes towards science, the attitudes prior to the exposure were compared to the attitudes after exposure using a dependent means t-test and were assessed for statistical significance at $\alpha = .05$. Looking at the extent to which participants liked different courses, there was a significant strong positive correlation between Physics and Chemistry, $r = .65$, $p = .00$. Since the two courses were similarly rated, they were averaged together for the remaining analyses.

Prior to exposure, all participants significantly preferred Biology ($M = 3.5$, $SD = 1.1$) more than Physics and Chemistry ($M = 2.9$, $SD = 1.2$), $t\ (27) = 2.15$, $p = .04$. However, after exposure, participants liked Biology ($M = 3.5$, $SD = 1.2$) as much as they liked Physics and Chemistry ($M = 3.2$, $SD = .99$),$t\ (27) = 1.\ 07$, $p = .31$. Thus, the exposure to different areas seems to have equalized interest in Biology, Chemistry, and Physics. There were no other significant differences between attitudes towards any of the other courses prior to or after exposure (Art, Biology, Chemistry, English, History, Math, Physics), p's> .1 (See Figure 1 and Table 1 for descriptive statistics).

Does Gender Play a Role?

Another question is whether the stereotype that women prefer liberal arts oriented courses over science courses (and vice versa) holds true. Looking at the extent to which participants liked different courses, there was a significant strong positive correlation between English and History, $r = .47$, $p = .01$. Since the two courses were similarly rated, they were averaged together for the analysis. We examined whether men and women differed in their liking of Liberal Arts and Science (Biology, Chemistry, and Physics) courses prior to exposure using a mixed models ANOVA where the ratings for Liberal Arts and Science were the within subject factors and the participants gender was the between subjects factor. There was no significant interaction between participant's gender and their ratings for the different science courses, F (1, 25) = .14, p = .72. We also examined whether women and men attitudes differed after exposure to the different areas of science. There, again, was no significant interaction between participant's gender and their ratings for different science courses, F (1, 11) = .19 p = .67[1]. See Table 2 for descriptive statistics.

Another remaining question is whether women and men differ in their attitudes towards different areas of science, especially if women preferred Biology more than men, as past research found (Berryman, 1983; LuckenBills-Eds, 2000). To examine this, we compared men and women's attitudes towards Biology and Chemistry and Physics prior to exposure using a mixed models ANOVA where the ratings for Biology and Chemistry/Physics were the within subject factors and the participants gender was the between subjects factor. There was no significant interaction between participant's gender and their ratings for the different science courses, F (1, 25) = .59, p = .45. We also examined whether women and men's attitudes changed after exposure to the different areas of science. There, again, was no significant interaction between participant's gender and their ratings for different science courses, F (1, 11) = 2.2, p = .17[2]. See Table 2 for descriptive statistics.

Discussion

Overall, as predicted, the results of our study suggest that exposing students to different areas of science (in fun and engaging ways) can help to increase the interest of students in different (and sometimes less popular) areas of science. However, unlike past research and our predictions that

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1 Note: Prior to Exposure, we had ratings from 13 men and 14 women. After Exposure, we had ratings from 4 men, and 9 women.

2 Note: Prior to Exposure, we had ratings from 13 men and 14 women. After Exposure, we had ratings from 4 men, and 9 women.

women prefer liberal arts and men prefer science (Cadinu, Maas, Rosabianca, & Kiesner, 2005; Johnston & Malinen, 2007; Nosek, Banaji, & Greenwald, 2002; Sinclair, Hardin, & Lowery, 2006), we found that our men and women students have equal interest in both science and liberal arts. In addition, while past research suggests that science oriented women typically prefer biology (LuckenBills-Eds, 2000; Ngo & Souza, 2007), we found, contrary to our predictions, that both men and women enjoyed biology more than physics and chemistry prior to exposing them to different areas of science. We also found that interest in the less popular physical sciences (physics and chemistry) increased equally for men and women after exposure.

By creating an after school science club program, we were able to prevent interfering with the high school's curriculum. However, one limitation to the above findings is that the sample may be less representative than a random sample of students because the students that participated may have had a higher initial interest in science than other students because they volunteered to participant in an after-school science club program. To try to increase the randomness of the sample, some teachers offered extra credit to their students. In addition, the sample size varied each week as the participants were not always able to attend every after school science club meeting. Given these limitations, future research should investigate methods that allow both a better retention rate over time of participants and allows for a larger, more representative sample of students (e.g., equal numbers of men and women) to further explore the benefits of exposing the students to the different areas of science. In addition, these changes will also help solidify whether a change in attitudes exists for all students—as our study found, contrary to previous research, that men and women have equal interests in science, liberal arts, and biology.

While we know that attitudes towards science were equal amongst both men and women students and we know that both men and women preferred biology, it is unclear what exposure means for the future of these students. Increased interest does not necessarily mean increased pursuit of these fields as a career. Future research should consider longitudinal methods in order to understand how increasing the interest in different areas of science manifests itself with students. It is possible that the increased interest is limited in time and once the women students start seriously pursuing majors or careers in these areas that societal pressures, stereotypes, and prejudices may still come into play and discourage those from continuing to pursue a major or career in that field.

In addition, our study begins to extend past research by incorporating engineering (e.g., having students build bridges to discuss civil engineering and physics)—a topic that has not garnered as much attention as science, math, or liberal arts in past research in academic and gender stereotypes. Incorporating engineering into our understanding of academic and gender stereotypes is important because while the number of women enrolled in colleges and universities exceeds men (in 2005, 43% of women and 35% of men were enrolled in college; see Mather & Adams, 2008), the enrollment of women in undergraduate and graduate institutions that specialize in math, science, and engineering does not replicate this pattern. For example, in 2007, only about 25% of the students enrolled at Worcester Polytechnic Institute and Rensselaer Polytechnic Institute were women. Thus, future research should focus on attitudes towards engineering to determine if the research done on math, science, and liberal arts attitudes also extends to engineering, and to see if the same techniques that may help improve attitudes towards women in science and math will work for engineering.

Future research may also consider social situational components that could influence attitudes as well, such as the gender and/or attitudes of the experimenters. For instance, in our study, both a men and women experimenter—who both expressed great interest in science—ran the study and potentially served as role models to the students[3]. The cross-gender of experimenters was done to ensure that the gender of the experimenter played a minimal role in the study. However, it is possible that the gender of the experimenter and their academic interests could have a subtle influence on participants.

[3] A possible limitation of our study was that the male experimenter was a chemistry major and the woman experimenter was a biology major, and this unintentionally could have confirmed the stereotype that women who are interested in science study biology (Ngo, Souza, 2007). However, since male and woman participants expressed interest in biology over physics and chemistry and since exposure worked similarly for both groups, it is unlikely the experimenter's interests had an effect in our study. However, future research should consider this variable.

Therefore, future research may consider manipulating both the gender of the experimenter who runs the sessions and also the interest of the experimenter (e.g., women interested in biology, women interested in chemistry, etc.) to determine whether these manipulations alter the explicit and implicit attitudes of the students, their interest in different areas of science, and any longitudinal implications.

In conclusion, the current study set out to explore a mechanism that could help improve attitudes towards women in science. While our research showed no gender differences in preferences towards science or biology (unlike past research), it provides preliminary evidence that providing mere exposure (Zajonc, 1968) to different areas of science (in fun, engaging, and thought-provoking ways) can help improve attitudes towards different, even less popular, areas of science.

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Table 1

Means and Standard Deviations for Attitudes Towards Biology and Chemistry/Physics

Exposure	*N*	*M*	*SD*	*t*	*p*
Prior				2.146	.04
Biology	28	3.50	1.11		
Chemistry/Physics	28	3.15	0.98		
After				1.072	.31
Biology	13	3.54	1.2		
Chemistry/Physics	13	3.15	.987		

Table 2

Means and Standard Deviations for Attitudes Towards Biology and Chemistry/Physics based on gender.

Exposure	*N*	*M*	*SD*	*F*	*p*
Prior				.59	.45
Biology, Men	13	3.38	1.12		
Biology, Women	14	3.64	1.01		
Chemistry/Physics, Men	13	3.04	1.53		
Chemistry/Physics, Women	14	2.86	.92		
After				2.2	.17
Biology, Men	4	3.25	1.71		
Biology, Women	9	3.67	1.00		
Chemistry/Physics, Men	4	3.63	1.38		
Chemistry/Physics, Women	9	2.94	.76		

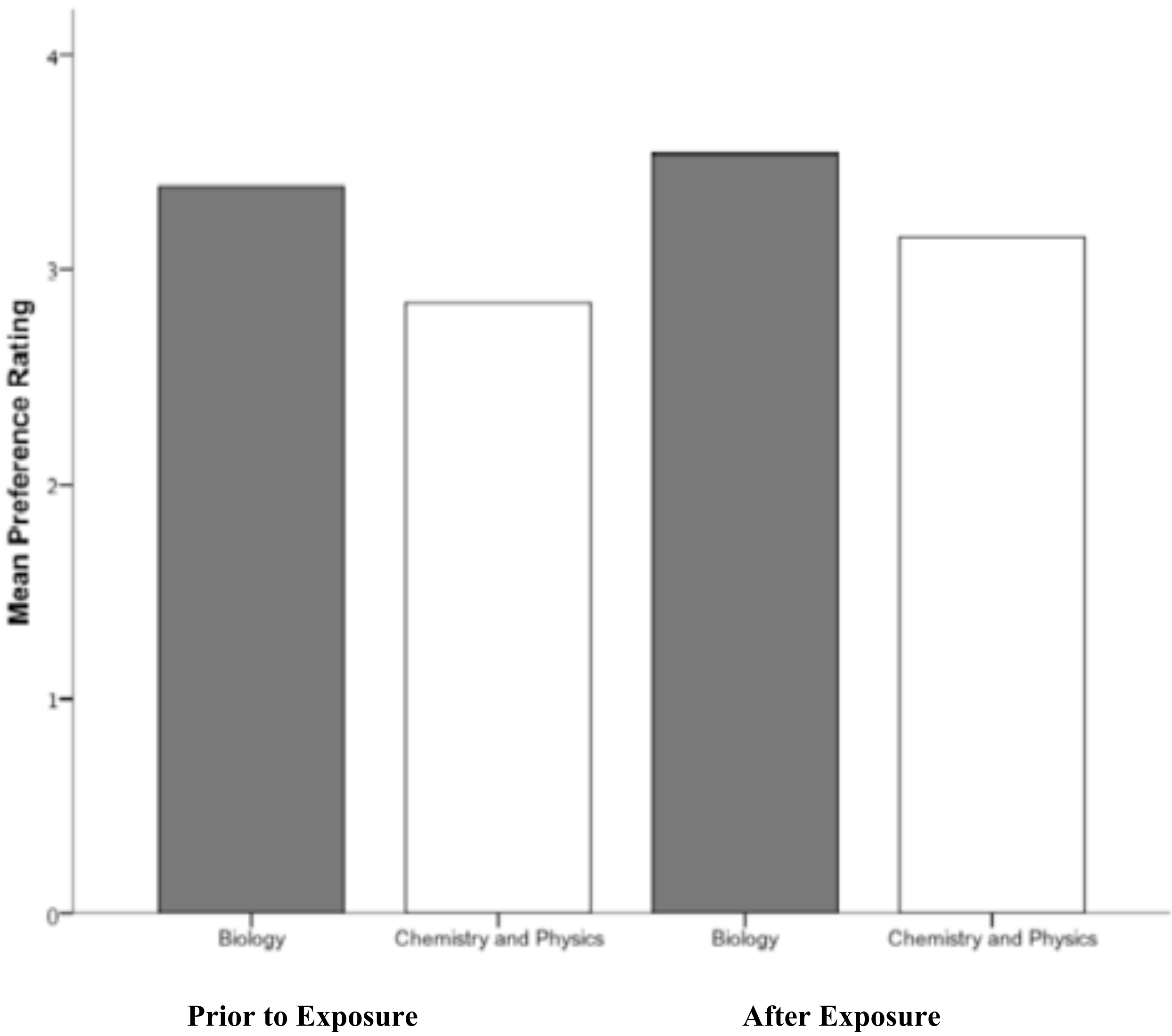

Figure 1. The effects of exposure on preferences towards different areas of science.

Appendix A

Project 1:M&Ms Survival

Topics Explored: Biology

Materials Needed:

3 Bags of M & Ms

Colored construction paper

Stopwatch

Project Procedure:

The students were each given a plastic bag with a predetermined amount of M&Ms, 5 of each color, two of the bags had red but no brown M&Ms and vice versa. Each of the bags were grouped with a matching piece of colored construction paper, i.e. if a bag had all colors but red then it could not be used with a red piece of paper. The M&Ms were scattered on a piece of the paper and students had 10 seconds to eat as many as possible, the results of how many M&Ms remained were recorded and sorted by color.

Project Purpose:

This project exposes students to experimental design and biological concepts. First, the experiment is purposefully flawed in that not all the bags had the same colors. This enables a discussion with students on what they would change to make it into a working experiment. In addition, this project enables discussion on the advantages of camouflage in the wild, and how adaptive camouflage is in terms of biological survival.

Project 2: Popsicle stick bridge building

Topics Explored: Civil Engineering, Stress analysis, Physics

Materials:

Popsicle Sticks

Wood Glue

Project Procedure:

Each team was provided with a bag of popsicle sticks and wood glue. Elements of structural stability (including the strongest shape) were first discussed. Students then brainstormed possible building ideas and started to build their bridge. The students were informed that their bridges would be tested for strength by placing a brick on it—and elements of physics were discussed.

Project Purpose:

This project gave students an insight into engineering design and analysis as well as project planning. This project required planning and group work two important aspects of engineering projects.

Project 3: Colloids

Topics Explored: Material Science

Materials:

Corn Starch

Water

A bowl

Project Procedure:

The activity started with discussion on non-newtonian fluids (ketchup for instance) and the properties they had. Multiple bowls were prepared with different ratios of water to corn starch in order to show students the importance of trial and error and also to determine the ratio the generated desired consistency. After colloid was made, the properties of the material were tested. For instance, when we applied fast and forceful pressure on it with our hands, the colloid appeared to be more solid-like; however, when we applied slow gentle pressure on it, the colloid appeared to be a liquid.

Project Purpose:

The projects allows for a discussion and demonstration of the properties of colloids, non Newtonian fluids, and the process of trial and error. The project also allows for discussion on the possible uses for materials that use colloids.

Project 4: Candy Chromatography

Topics Explored: Analytical Chemistry

Materials:

6 Coffee Filters

1 large bag of Skittles

Colored dye (any amount)

12 Straws

12 Dixie cups

Project Procedure:

Coffee filters were used as a chromatography paper. In order to use them in this way the coffee filters were cut into strips (.5 x 2 inches). A line was drawn an 1/8 inch from one end with the other end taped to straws and set aside for use later. In order to create a water-soluable dye, the skittles were soaked in water so to isolate the dye from the candy. Using pipettes we transferred a drop of the candy solution and a drop of food coloring, for comparison, to the chromatography paper. A Dixie cup was prepared with a small amount of water in the bottom and by taping the chromatography paper to a straw it was placed into the cup so just the end of the paper was immersed in the water. The colored dye from the skittle-dye and the food coloring should be carried up the chromatography paper through capillary actions. The chromatography paper was allowed to sit for a short period of time so the water could soak up the paper. Afterwards the Rf values, distances from the starting line, were recorded and a group discussion occurred.

Project Purpose:

This project allows discussion and demonstration of analytical chemistry. The project allowed students to conduct a mini-experiment and analyze the results (the Rf values) from the Skittle dyes to the food coloring dyes. We started by talking about the usefulness and importance of analytical chemistry in multiple aspects of the working world.

Project 5: Polymers

Topics Explored: Chemistry

Materials

Silly Putty

Gak

Project Procedure and Purpose:

The project allows for discussion of polymers and the physical and chemical properties behind them. This project also allows for elaboration into polymers in the real world and can allow for discussion of polymers that exist in the classroom environment.

Project 6: Yogurt

Topics Explored: Biology: Cell Cultures

Yogurt

Materials

Yogurt

Yogurt making machine

Milk

Note: Quantities may vary depending on what "recipe" you use

Project Procedure:

By making yogurt in class, this project demonstrates the properties of bacteria cultures and allows for discussion on bacteria, foods that are made using bacteria cultures, and the benefits of some bacteria. The process of making yogurt was presented to the students and discussion occurred on bacteria cultures and what exactly yogurt is.

Project 7: Pickle battery

Topics Explored: Electrical Engineering: Electricity and Circuits

Materials:

1 Pickle

1 Buzzer

1 Sheet Tin foil

1 Pencil

2 Wires

Project Procedure:

A pickle was prepared by cutting a slit into the side of it, the tin foil was inserted into that slit so that about a sixth of it was fully submerged in the pickle. A portion of the pencil two inches from the tip was removed so that the graphite was still showing. The tip of the pencil was then inserted into the pickle. The wires were attached to the exposed graphite and tin foil and connected to the small horn. If the experiment had gone correctly the horn would have sounded and a complete circuit would have been made.

Project Purpose:

Students learned about current flow in a circuit and had a brief introduction to electro negativity.